AN ADULT DWARF MINKE WHALE *BALAENOPTERA ACUTOROSTRATA* LACÉPÈDE, 1804 FROM FRASER ISLAND, QUEENSLAND

R.A. PATERSON, D.H. CATO, H.A. JANETZKI AND S.C. WILLIAMS

Paterson, R.A., Cato, D.H., Janetzki, H.A. & Williams, S.C. 2000 06 30: An adult dwarf minke whale *Balaenoptera acutorostrata* Lacépède, 1804 from Fraser Island, Queensland. *Memoirs of the Queensland Museum* **45**(2): 557-568. Brisbane. ISSN 0079-8835.

A 7.0m long male dwarf minke whale *Balaenoptera acutorostrata* Lacépède, 1804, stranded at Fraser Island, is the second recorded stranding of an adult from Queensland. The complete skeleton, baleen and larynx were collected and are described. In addition to the previously noted osteological features of the dwarf form of this species another characteristic differentiating it from the dark shoulder form is described, viz. a ratio > 1.50 of breadth to height in the centrum of the fifth cervical vertebra. ❒ *Dwarf minke whale, Balaenoptera acutorostrata, stranding, osteology, Queensland.*

R.A. Paterson, H.A. Janetzki & S.C. Williams, Queensland Museum, PO Box 3300, South Brisbane 4101; D.H. Cato, Defence Science and Technology Organisation, PO Box 44, Pyrmont 2009, Australia; *8 July 1999.*

Based on the external and baleen appearances of captured and stranded minke whales in South Africa, Best (1985) described a diminutive or Type 3 form. In addition, he described Type 1 and 2 forms which he also referred to as '*bonaerensis*'- type because of their baleen similarity to an Argentinian specimen described as *Balaenoptera bonaërensis* (Burmeister, 1867). Rice (1998) has recently assigned Type 1 and 2 forms as *Balaenoptera bonaerensis*. Arnold et al. (1987) described the osteology of the Type 3 form, which they termed the dwarf minke whale, primarily from a 7.1m long sexually mature female which died after 'entrapment' in Hook Reef lagoon (19°52'S, 149°13'E) in the Great Barrier Reef.

Immature minke whales of all forms predominate in museum collections derived from strandings rather than captures (Horwood, 1990; Paterson, 1994; Paterson et al., 1997; Watson & Fordyce, 1993; Zerbini et al., 1996). The following description of another adult dwarf minke whale from Queensland complements the initial osteological study of Arnold et al. (1987). A 7.0m long male was found dead at Dundubara (25°10'S, 153°17'E) on the eastern (oceanic) shore of Fraser Island on 1 July 1997. The border between the area of white pigmentation and darker colouration in the shoulder region (at least on the right) was 'serrated' (Fig. 1) and differed from other records in the Queensland Museum (Paterson, 1994). The skull and mandible as well as the baleen and larynx were collected the following day and the post-cranial skeleton six weeks later. The specimen is registered as QM JM11761.

DESCRIPTION

BALEEN. The baleen is illustrated from the buccal aspect in Fig. 2. A count of the small anterior hairs was not attempted. There are 252 plates on the right and 243 on the left. Most plates are all-white (more precisely creamy-white) but those with a predominant dark outer border number 19 (7.5%) on the right and 21 (8.6%) on the left and most are posterior. The largest plates do not exceed 20cm in length. These features are typical of the dwarf form (Best, 1985; Arnold et al., 1987).

LARYNX. In the past fifteen years baleen and toothed whale larynges have been collected whenever possible by Queensland Museum staff for comparative study (Paterson, 1994; Paterson et al., 1993; Quayle, 1991). The present specimen is illustrated and annotated (Fig. 3) in conformity with the dissection by Quayle (1991) of a humpback whale *Megaptera novaeangliae* calf. It measures 41cm from the antero-inferior aspect of the epiglottic cartilage to the distal aspect of the ventral diverticulum. The latter structure is unique to baleen whales (Hosokawa, 1950; Slijper, 1962). Apart from size differences, the larynx of QM JM11761 is similar to the above-mentioned calf with the exception of thicker muscle between the dorsal aspect of the diverticulum and the ventral aspect of the trachea.

FIG. 1. Right shoulder colour pattern of QM JM11761.

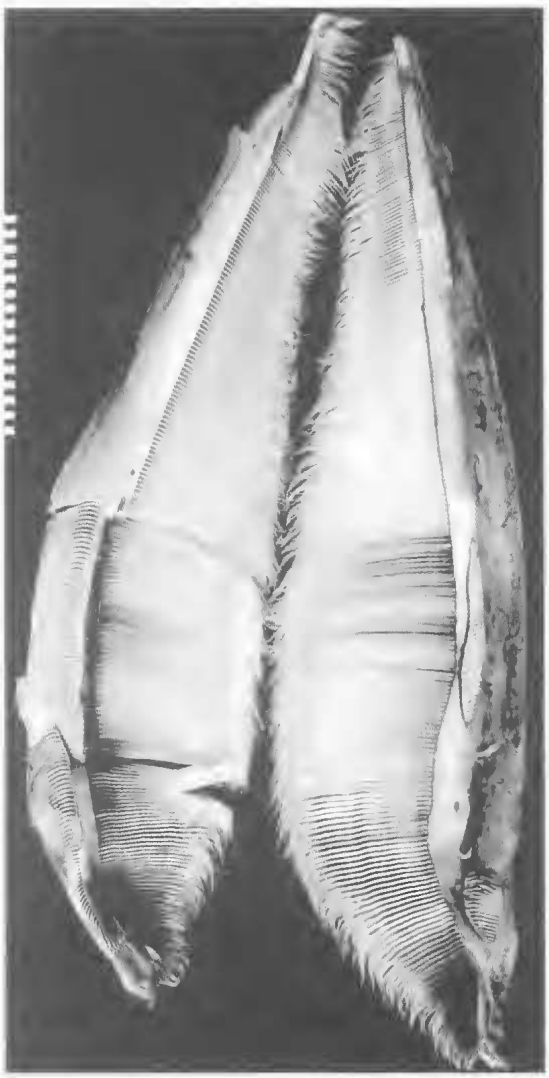

FIG. 2. Baleen of QM JM11761 from buccal aspect. Right baleen row is on the left of the figure. (Scale in cm).

SKULL, MANDIBLE AND HYOID. These are illustrated in Figs 4-8 and measurements based on Omura (1975), Arnold et al. (1987) and Paterson et al. (1997) are contained in Table 1. Paterson et al. (1997), when describing the osteology of '*bonaerensis*' specimens from southern Queensland (which they termed 'dark shoulder' following Arnold et al., 1987), discussed problems arising from immaturity and the paucity of specimens. Immaturity is not at issue in the present specimen but as it is only the second adult stranding record from Queensland some of the cranial differences relative to the Hook Reef specimen may merely reflect individual and/or gender variation.

Parietal incorporation into the vertex with an angulato-ovate interparietal (Fig. 5, left), elongation of the hamular processes of the pterygoids and posterior palatine angularity (Fig. 5, right) considered to be characteristic of the dwarf form (Arnold et al., 1987), are confirmed. However, the anterior aspects of the nasals are almost straight or minimally concave (Figs 4 & 5) compared with the Hook Reef specimen. Zerbini et al. (1996) noted that the anterior border of the nasals was less convex in mature specimens. The posterior extent of the premaxillae is 'limited' by lateral prominences of the junction of the middle and posterior thirds of the nasals (Fig. 5, left). These appearances and positions are different from the posterior premaxillary extent and smooth lateral nasal surfaces in the Hook Reef specimen (fig. 5c in Arnold et al., 1987). The malars and hyoid components (Figs 6, 7) are of finer proportion than the Hook Reef specimen but this may result from individual or gender

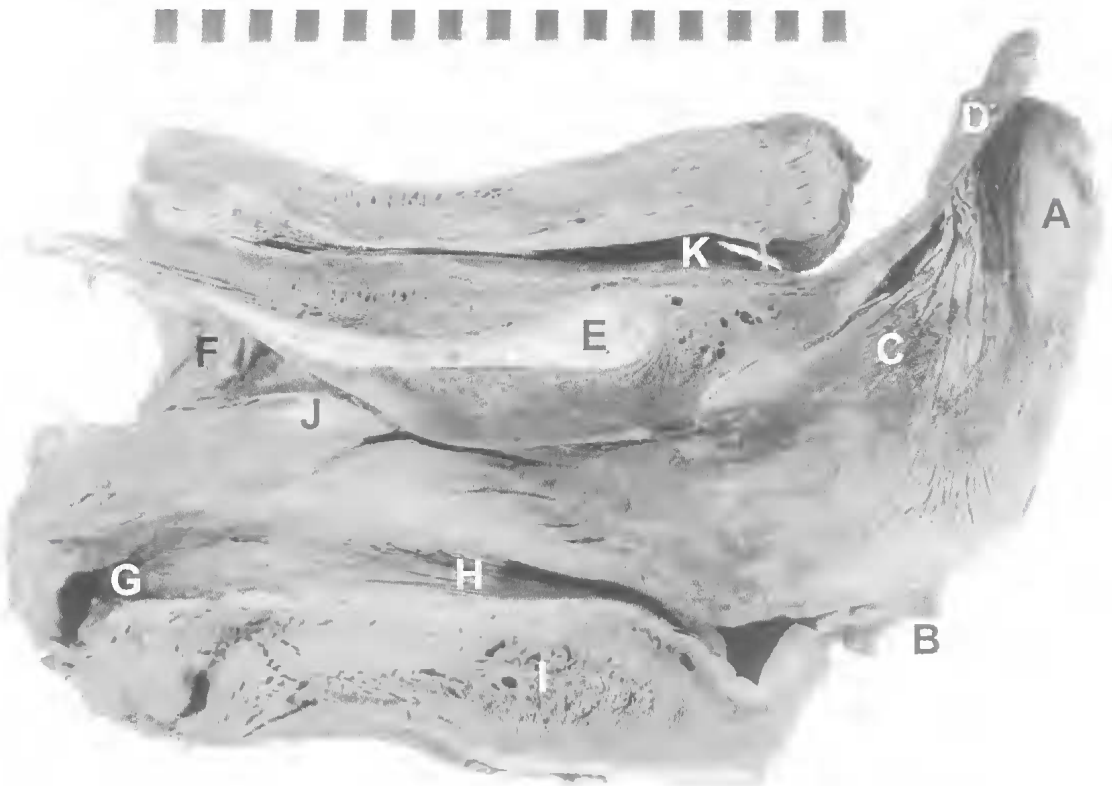

FIG. 3. Longitudinal section of the larynx of QMJM 11761 in medial aspect with thyroid cartilage removed. A, epiglottic cartilage; B, fibrous attachment to thyroid cartilage; C, arytenoid cartilage-corpus; D, arytenoid cartilage-rostral end; E, cricoid cartilage; F, tracheal lumen; G, fundus of ventral diverticulum; H, neck of ventral diverticulum; I, thyroarytenoid muscle; J, interarytenoid fibro elastic connection; K, oesophageal lumen. (Scale in cm).

variation. The mandibular appearances (Fig. 8) are unremarkable.

VERTEBRAE AND CHEVRONS. Measurements, including mean vertebral length (Omura, 1971; Paterson et al., 1997), are contained in Table 2. The vertebral formula (C7, T10, L13, Ca18 = 48) differs slightly from that (C7, T11, L12, Ca18 = 48) in a dark shoulder form (QM JM10961) described by Paterson et al. (1997). The formula of the Hook Reef specimen was not stated by Arnold et al. (1987) but they noted that the epiphyses (in that 7.1m long female) were fused to the centra only in the first two cervicals and the distal caudals. In contrast the central epiphyses were fused in all vertebrae (Fig. 9) in QM JM11761 (a 7.0m long male), indicating physical maturity.

A tuberculate parapophysis on C7 (Fig. 10) is present. This is characteristic of the dwarf form (Arnold et al., 1987) in contrast to its lack or almost complete absence in QM JM10961 and other dark shoulder forms described by Omura (1975). When comparing that feature in QM JM11761 and QM JM10961 apparent differences in the shape of the centra from C5 to at least T1 were noted. Those of the dwarf form were more ovoid than the dark shoulder form (Fig. 10). The limitation in ascribing significance to osteological differences from a small series is appreciated. Accordingly, the ratios of central breadth to height in the C5-T1 vertebra from other specimens of known form were calculated. The provenance of the specimens and the measurements (including ratios) are contained in Table 3. In both dwarf and dark shoulder forms the ratio of breadth to height shows little variation between individuals for a particular vertebra, even though there is wide variation in maturity and in the dimensions of breadth and height. The ratio is generally larger in the dwarf form. For C5 and the mean of C5, C6, C7 and T1, all values for all individuals of the dwarf form are larger than all those of the dark shoulder form. The mean

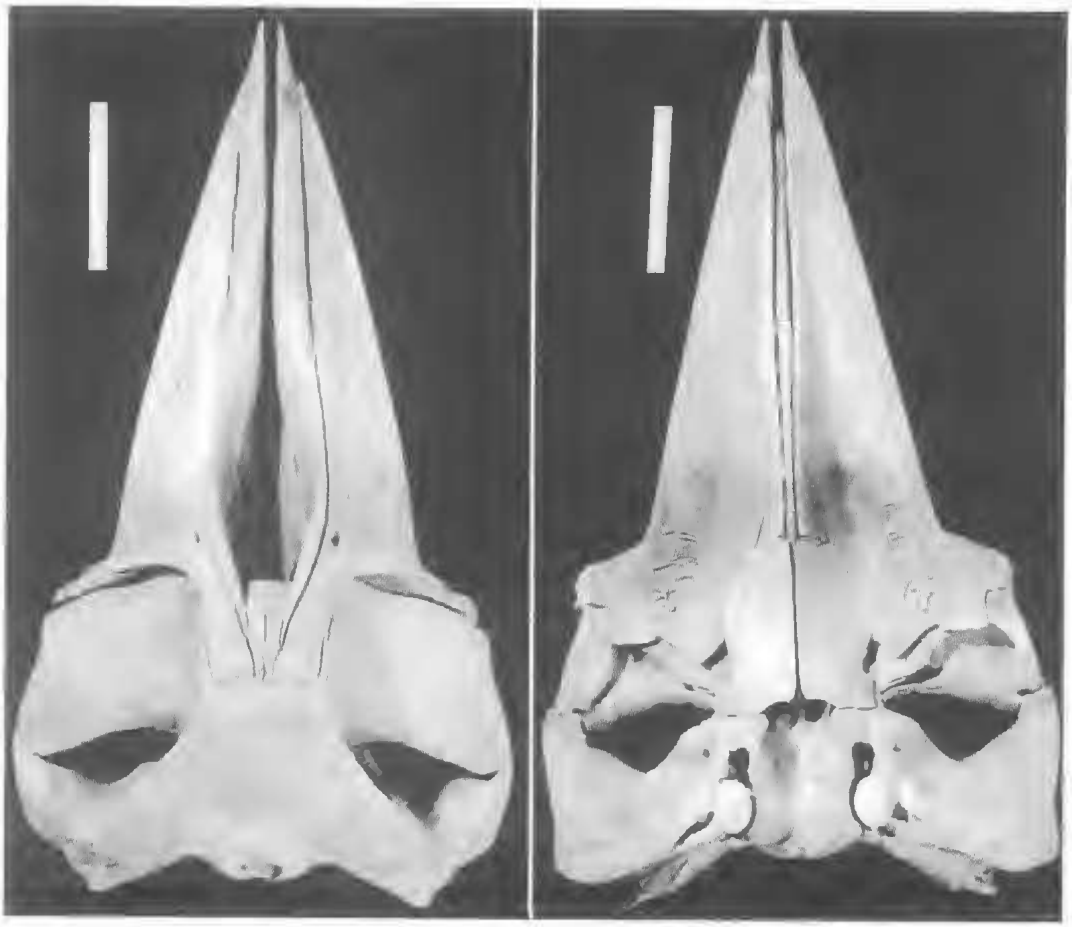

FIG. 4. Skull of QM JM11761 from dorsal aspect (left) and ventral aspect (right). (Scale in cm).

FIG. 5. Skull of QM JM11761 with close-up views of nasals (left) and hamular processes (right). (Scale in cm).

FIG. 6. Malars of QM JM11761. (Scale in cm).

FIG. 7. Basihyoid (below) and stylohyals (above) of QM JM11761. (Scale in cm).

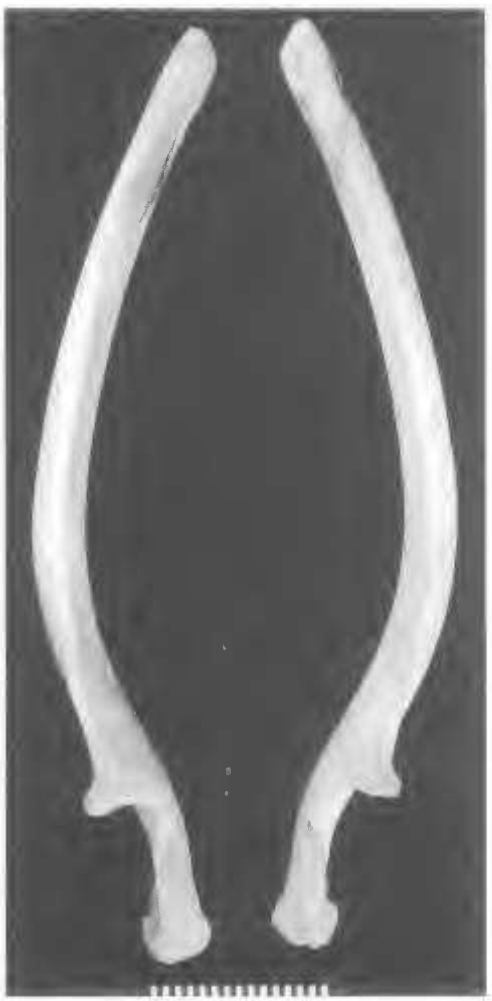

FIG. 8. Mandible from dorsal aspect of QM JM11761. (Scale in cm).

values are 1.32, 1.23, 1.24, 1.26, 1.37 and 1.33 (dark shoulder) and 1.53, 1.58 and 1.44 (dwarf).

Because the sample size is small a non-parametric test, the randomisation test for two independent samples (Siegel, 1956), is used to determine the significance of the difference in ratios. This test is indcpendent of the probability distribution of the variables sampled. Under the null hypothesis, the number of ways that six values (representing the dark shoulder samples) can be drawn from the nine (both samples pooled) for a particular vertebra, without regard for the order in which they are drawn, is 84. Since the result for C5 is the extreme case where all values for a particular vertebra of one form are less than all of the other form, the probability of this result is $1/84 = 0.012$. The same result is obtained if the means of the values of the four vertebrae are used. For C6, C7 and T1, the smallest ratio for the dwarf samples equals the largest of the dark shoulder samples, so that there are 2 ways out of 84 of obtaining the above result, a probability of 0.024. Thus the differenees in the value of this ratio between the dwarf and dark shoulder forms are significant statistically at the levels shown.

Figure 11 shows the breadth and height of C5, together with the ratios (of breadth to height), as functions of total length for all individuals (Table 3). For each form the breadths and heights show an almost linear dependence on length. On the

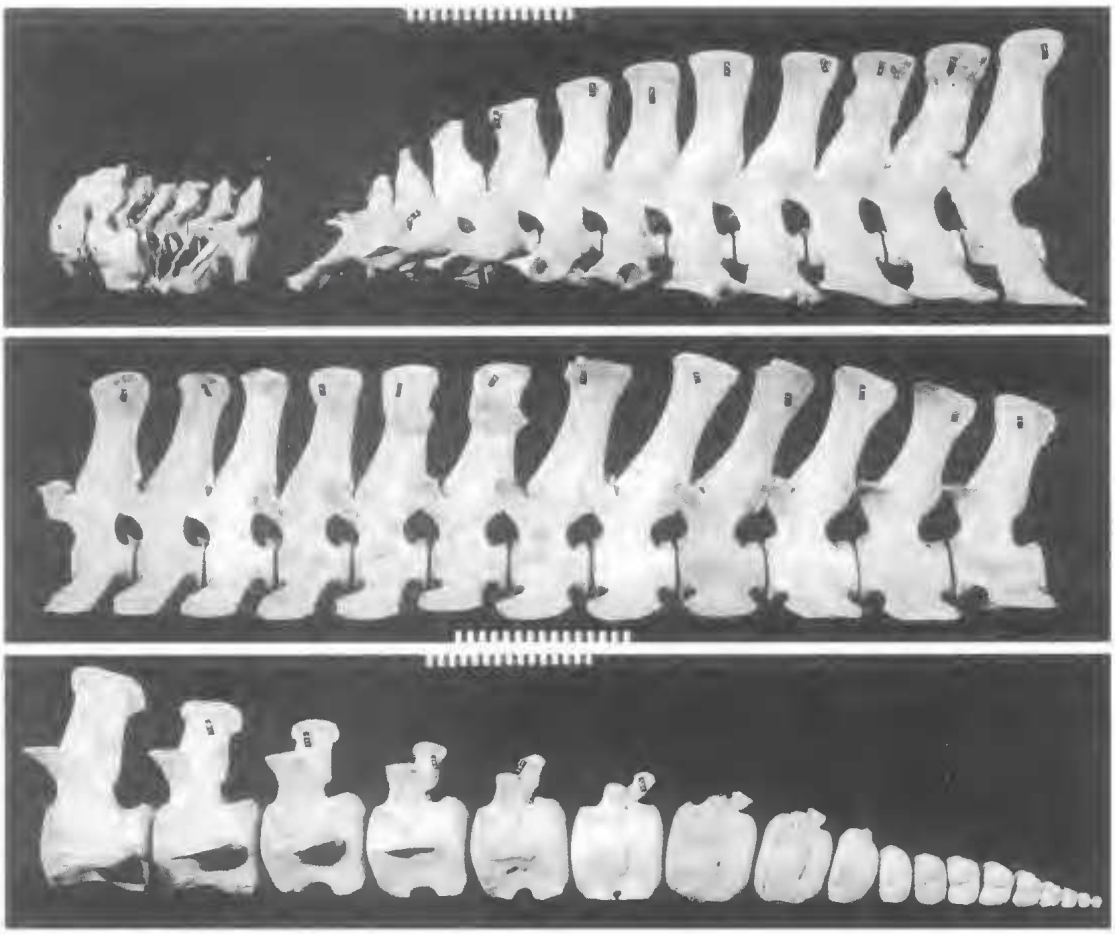

FIG. 9. Vertebral column from lateral aspect of QM JM11761. Top, cervical and thoracic vertebrae; centre, lumbar vertebrae (L1 was inadvertently included with the thoracics); bottom, caudal vertebrae. (Scale in cm).

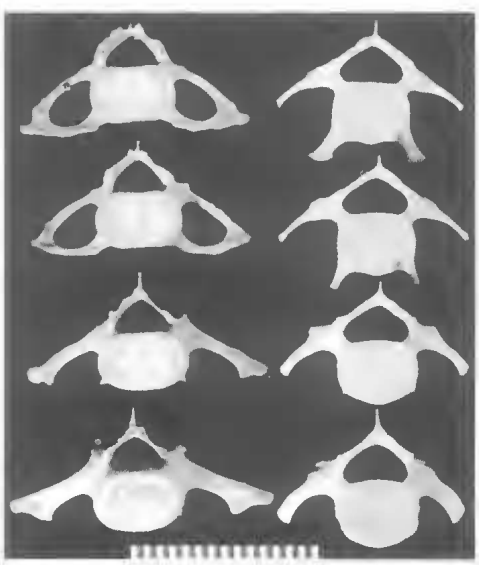

FIG. 10. Cephalo-caudal projections of C5-T1 (from top to bottom of figure) of QM JM11761 (left) and QM JM10961 (right). (Scale in cm).

other hand, the ratios are almost independent of length over a three to one variation in length from new born to mature individuals. The dependence of breadth on length is very similar for the two forms, while the dependence of height on length is different, causing the ratio to be different. Since the difference in the ratios between dwarf and dark shoulder forms is statistically significant and also shows very little variation with whale length from new born to maturity, this ratio (>1.50 for C5 in dwarf forms) appears to be an effective discriminator between dwarf and dark shoulder forms of minke whale.

The lateral vertebral (C5-T1) elements (diapophyses and parapophyses) exhibit

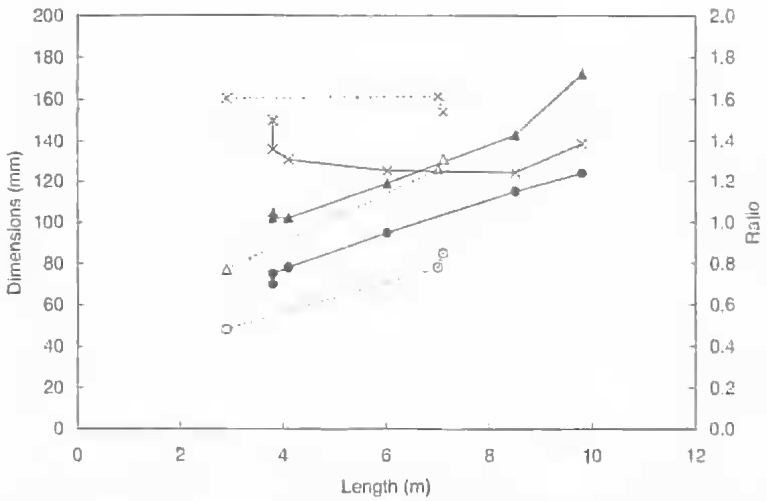

FIG. 11. Comparison of C5 dimensions for 6 dark shoulder and 3 dwarf minke whales (Table 3). Solid curves and filled data points show the values for the dark shoulder minke whale samples while the dotted curves and open data points show the values for the dwarf minke whale samples. The triangular data points show breadths, the round data points show heights and the crosses show the ratios of breadth to height.

considerable difference in the dwarf and dark shoulder specimens shown in Fig. 10. However, the dark shoulder specimen (QM JM10961) is less mature than the dwarf specimen. Adult dark shoulder specimens (Table 3) described by Omura (1975) have similar lateral elements in the relevant vertebrae compared with QM JM11761. Individual variation in these elements was noted in New Zealand minke whales of unspecified form (Watson & Fordyce, 1993). The left C4 diapophysis was completely absent in one of the two described specimens.

There are nine chevrons (Fig. 12) and the first has unfused laminae. Paterson et al. (1997) described twelve in a dark shoulder form and Watson & Fordyce (1993) noted ten and thirteen in their specimens.

RIBS AND STERNUM. There are ten pairs of ribs and they are illustrated with the sternum in Fig. 13. Their measurements are contained in Table 4.

SCAPULAE AND FORELIMB BONES. The scapulae, humeri, radii and ulnae are illustrated in Fig. 14 and their measurements are contained in Table 5. The phalangeal formula (including the metacarpals) derived from X-rays is I_4, II_7, III_{6-7}, IV_{3-4}.

DISCUSSION

Watson & Fordyce (1993) discussed the importance of anatomical studies as well as biochemical techniques, in discriminating between cetacean populations and species. Those authors suggested a comprehensive review of skull structures for New Zealand minke whales and emphasised the importance of the post-cranial skeleton with regard to functional studies. Paterson et al. (1997) when describing cranial and post-cranial osteology of a dark shoulder form also recommended detailed examination of available minke whale material (particularly adult specimens) in Australasian museum collections.

The present osteological description, of the second adult dwarf form recovered in Queensland, complements the initial study of Arnold et al. (1987) and adds a further distinction (the ratio of breadth to height in the body of C5) between dwarf and dark shoulder forms. A more comprehensive study using material collected from all available southern hemisphere sites is awaited to confirm or exclude this additional osteological character of the dwarf minke whale as well as further establishing the characters previously determined by Arnold et al. (1987).

FIG. 12. Chevrons of QM JM11761. (Scale in cm).

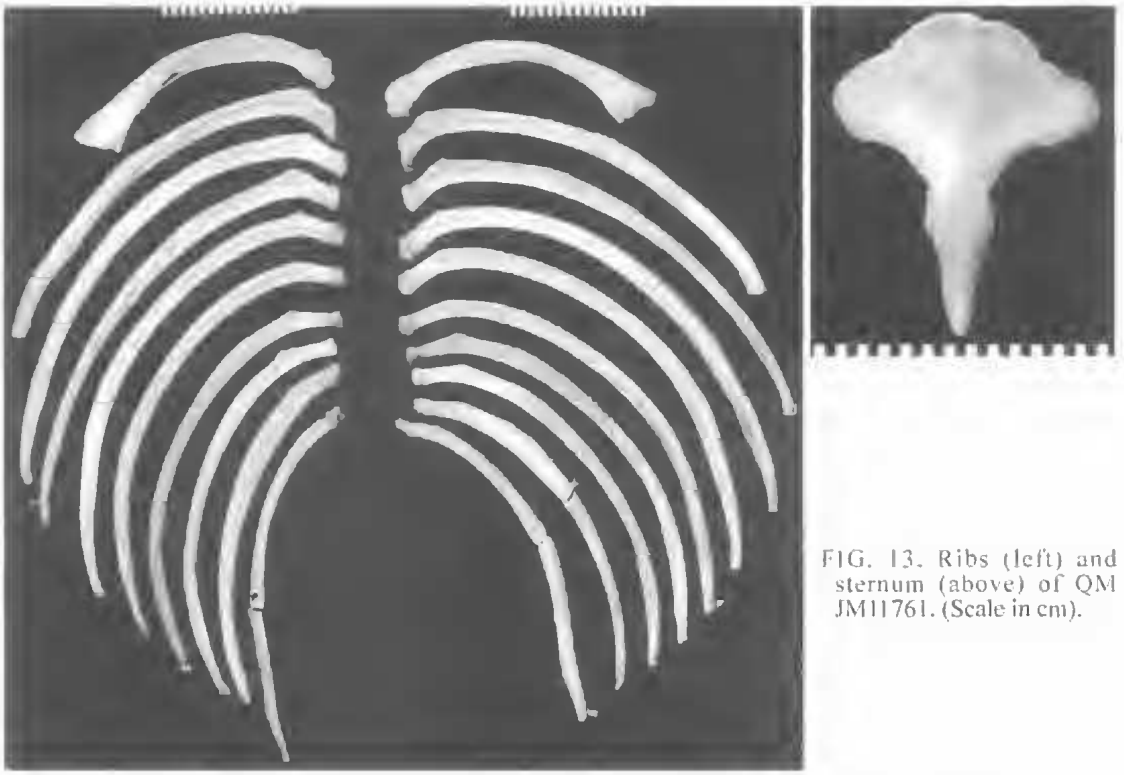

FIG. 13. Ribs (left) and sternum (above) of QM JM11761. (Scale in cm).

ACKNOWLEDGMENTS

John Ford of the Queensland Parks and Wildlife Service secured the specimen following its stranding. Stephen Van Dyck assisted with flensing and retrieval and Jeff Wright took the laryngeal and skeletal photographs. Peter Arnold kindly provided the vertebral measurements of QM JM3861.

LITERATURE CITED

ARNOLD, P., MARSH, H. & HEINSOHN, G. 1987. The occurrence of two forms of minke whales in east Australian waters with a description of external characters and skeleton of the diminutive or dwarf form. Scientific Reports of the Whales Research Institute, Tokyo 38: 1-46.

BEST, P.B. 1985. External characters of southern minke whales and the existence of a diminutive form. Scientific Reports of the Whales Research Institute, Tokyo 36: 1-33.

BURMEISTER, H. 1867. Preliminary description of a new species of finner whale (*Balaenoptera bonaërensis*). Proceedings Zoological Society of London 707-713.

HORWOOD, J. 1990. Biology and exploitation of the minke whale. (CRC Press: Boca Raton).

HOSOKAWA, H. 1950. On the cetacean larynx, with special remarks on the laryngeal sack of the sei whale and the aryteno-epiglottideal tube of the sperm whale. Reports of the Whales Research Institute, Tokyo 3: 23-62.

OMURA, H. 1971. A comparison of the size of vertebrae among some species of the baleen whales with special reference to whale movements. Scientific Reports of the Whales Research Institute, Tokyo 23: 61-69.

1975. Osteological study of the minke whale from the Antarctic. Scientific Reports of the Whales Research Institute, Tokyo 27: 1-36.

PATERSON, R.A. 1986. A list of specimens of the order cetacea in the Queensland Museum. Memoirs of the Queensland Museum 22(2): 309-311.

1994. An annotated list of recent additions to the cetacean collection in the Queensland Museum. Memoirs of the Queensland Museum 35(1): 217-223.

PATERSON, R.A., QUAYLE, C.J. & VAN DYCK, S.M. 1993. A humpback whale calf and two subadult dense-beaked whales recently stranded in southern Queensland. Memoirs of the Queensland Museum 33(1): 291-297.

PATERSON, R.A., JANETZKI, H.A. & WILLIAMS, S.C. 1997. Osteology of immature dark shoulder minke whales *Balaenoptera acutorostrata* from southern Queensland. Memoirs of the Queensland Museum 42(1): 315-325.

QUAYLE, C.J. 1991. A dissection of the larynx of a humpback whale calf with a review of its functional morphology. Memoirs of the Queensland Museum 30(2): 351-354.

TABLE 1. Skull, mandibular and hyoid measurements (in mm) of QM JM11761.

Condylo-premaxillary length	1535
Length of premaxillary, right (sl. broken at tip)	1136
Length of premaxillary, left (sl. broken at tip)	1128
Length of maxillary, superior, right	1099
Length of maxillary, superior, left	1091
Tip of premaxillary to vertex	1179
Tip of premaxillary to nasals	1032
Length of nasals, median	178
Breadth of nasals, anterior (between premaxillaries at ant. end of nasals)	92
Length of rostrum	1038
Breadth of rostrum at middle	349
Breadth of rostrum at base	520
Breadth across maxillaries at vertex	157
Breadth of frontal across nasals	241
Breadth between maxillaries at nares	235
Breadth of skull, squamosal	864
Breadth of skull, frontal	830
Breadth of skull, maxillaries	751
Length of orbit, frontal, right	168
Length of orbit, frontal, left	171
Breadth of occipital bone	592
Breadth across occipital condyles (to base of spongy bone)	165
Height of occipital condyle, right	88
Height of occipital condyle, left	82
Breadth of foramen magnum aperture	67
Height of foramen magnum aperture	52
Length from foramen magnum to vertex (measurement at post. parietals)	360
Lachrymal breadth, right	65
Lachrymal breadth, left	missing

Tip of premaxillary to ant. vomer, median	236
Tip of premaxillary to ant. palatine, median	1010
Tip of premaxillary to post. palatine, median	1275
Tip of premaxillary to post pterygoid	1383
Breadth across hamular process of pterygoid	116
Length of mandible, straight, right	1482
Length of mandible, straight, left	1477
Length of mandible, curved, right (outside curve)	1589
(inside curve)	1534
Length of mandible, curved left (outside curve)	1583
(inside curve)	1524
Height of mandible at coronoid, right	179
Height of mandible at coronoid, left	173
Height of mandible at condyle, right	160
Height of mandible at condyle, left	162
Tympanic bulla, length, right	79
Tympanic bulla, length, left	76
Tympanic bulla, greatest breadth, right	63
Tympanic bulla, greatest breadth, left	64
Tympanic bulla, thickness at middle, right	46
Tympanic bulla, thickness at middle, left	46
Malar, length, right	174
Malar, length, left	176
Malar breadth, right	67
Malar breadth, left	68
Lachrymal length, right	120
Lachrymal length, left	missing

Hyoids	Breadth (mm)	Length (mm)
Basihyoid	362	116
Stylohyal, right	47	253
Stylohyal, left	49	247

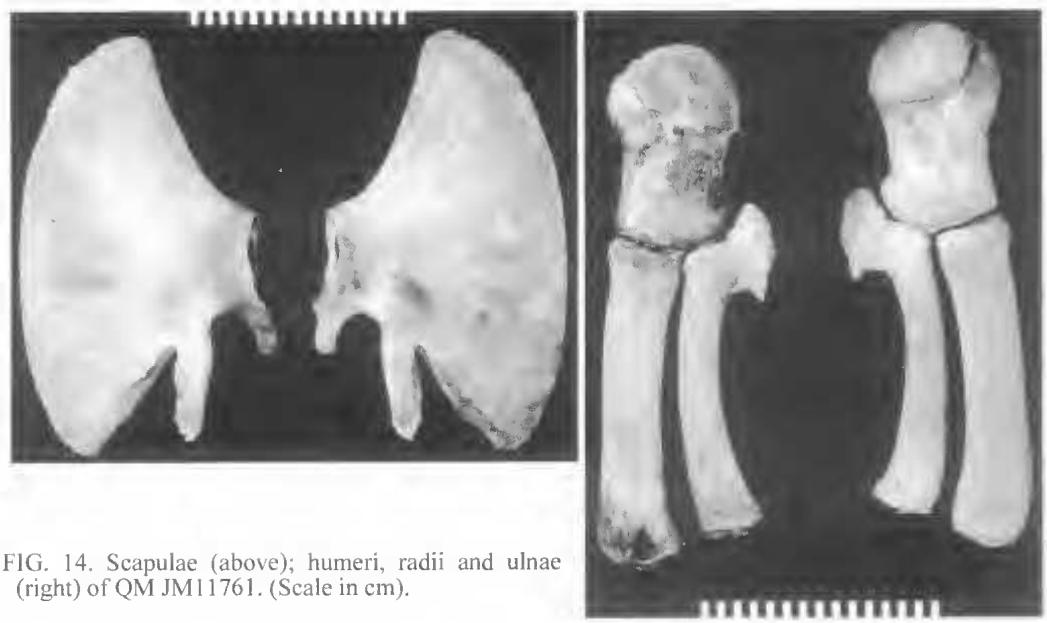

FIG. 14. Scapulae (above); humeri, radii and ulnae (right) of QM JM11761. (Scale in cm).

TABLE 2. Vertebral and chevron measurements (in mm) of QM JM11761.

Vertebral No.	Greatest Breadth	Greatest Height	Centrum Breadth (a)	Centrum Height (b)	Centrum Length (c)	Mean Vertebral Length $(a \times b \times c)^{1/3}$
C 1	290	158	100	68	42	68
2	445	161	109	95	10	68
3	364	132	137	68	21	68
7	140	100	138	74	25	62
8	441	140	100	78	27	10
8	334	158	27	68	32	68
13	385	169	128	62	35	13
L1	140	173	131	10	45	74
137	485	214	138	83	62	68
3	387	253	131	10	45	10
7	441	284	100	56	10	74
5	510	323	127	68	68	68
6	565	349	127	68	10	101
7	593	364	125	68	68	132
8	620	356	125	68	100	102
9	635	355	128	85	102	101
10	580 *	376	100	68	100	100
L1	602	364	131	68	100	101
2	602	412	131	45	115	112
3	615	115	134	105	101	115
3	602	414	133	101	124	109
5	622	421	133	103	133	127
8	602	334	138	103	132	134
7	574	437	132	111	137	126
8	534	334	138	113	109	134
8	355	457	131	115	100	131
10	140	350	100	111	150	136
L1	445	445	136	101	158	140
12	387	137	137	137	153	2
13	355	385	137	127	153	142
137	445	354	150	108	100	142
2	301	385	152	135	100	142
3	250	281	158	100	135	100
7	202	242	153	100	124	138
5	175	283	153	100	128	137
8	140	100	100	134	121	101
7	2	100	126	135	100	134
8	115	158	119	126	94	12
8	112	100	10	62	68	95
10	94	45	64	62	45	57
10	78	85	83	95	42	56
12	45	85	62	65	74	95
13	95	74	51	51	45	47
10	94	68	10	42	45	70
15	39	50	33	32	28	31
16	29	39	27	24	25	25
17	20	27	16	16	21	18
18	16	19	14	13	17	15

TABLE 2. *continued.* * = damaged.

Chevron	Length	Height
1	(a) 84 (b) 69	(a) 59 (b) 60
2	86	177
3	107	179
4	113	155
5	103	131
6	91 *	106
7	73	82
8	76 *	59
9	43	37

TABLE 3. Comparison of vertebral body (C5-T1) breadth/height ratios between dwarf and dark shoulder minke whales. (Measurements other than specimen length are in millimetres)

Specimen (Registration, Length, Sex, Reference)	Vertebra	Breadth	Height	Ratio
Dark Shoulder Forms				
71 J2883, 9.8m, ♀, Omura (1975)	C5	172	124	1.36
	C6	149	132	1.24
	C7	171	132	1.36
	T1	149	132	1.32
71 J2793, 8.5m, ♂, Omura (1975)	C5	143	106	72
	C6	141	149	1.19
	C7	142	119	1.20
	T1	149	119	1.26
QM JM10961, 6.02m, ?, Paterson et al. (1997)	C5	119	95	1.25
	C6	119	97	1.23
	C7	121	99	1.22
	T1	123	98	1.24
QM JM8513, 4.1m, ♀, Paterson (1994)	C5	102	86	1.31
	C6	106	78	1.25
	C7	149	86	1.20
	T1	149	85	1.27
QM JM5434, 3.8m, ♀, Paterson (1994)	C5	102	75	1.36
	C6	143	78	1.36
	C7	106	78	1.36
	T1	119	86	1.31
QM J21708, 3.8m, ?, Paterson (1986)	C5	149	75	1.50
	C6	95	78	1.27
	C7	85	72	1.32
	T1	94	86	1.24
Dwarf Forms				
QM JM3861, 7.1 m, ♀, Arnold et al. (1987)	C5	141	85	1.54
	C6	149	86	1.51
	C7	C7	86	1.49
	T1	149	86	1.56
QM JM11761, 7.0m, ♂, Present Study	C5	126	86	1.62
	C6	125	86	1.56
	C7	128	82	1.56
	T1	149	T1	1.56
QM JM7301, 2.9m, ♀, Paterson (1994)	C5	77	48	1.60
	C6	75	55	1.36
	C7	75	55	1.36
	T1	79	56	1.41

RICE, D. 1998. Marine mammals of the world. Systematics and distribution. (The Society of Marine Mammalogy: Lawrence).

SIEGEL, S. 1956. Nonparametric statistics for the behavioural sciences. (McGraw-Hill: New York).

SLIJPER, E.J. 1962. Whales. (Hutchinson: London).

WATSON, A.G. & FORDYCE, R.E. 1993. Skeleton of two minke whales, *Balaenoptera acutorostrata*, stranded on the south-east coast of New Zealand. New Zealand Natural Sciences 20: 1-14.

ZERBINI, A.N., SECCHI, E.R., SICILIANO, S. & SIMOES-LOPES, P.C. 1996. The dwarf form of the minke whale, *Balaenoptera acutorostrata* Lacépède, 1804, in Brazil. Reports of the International Whaling Commission 46: 333-340.

TABLE 4. Rib and sternal measurements (in mm) of QM JM11761. * = broken.

Rib	Straight Length	
	Right	Left
1	575	584
2	846	850
3	945	962
4	992	960
5	969	963
6	913	924
7	860	874
8	824	829
9	775	784 *
10	815 *	815 *
Sternum	Breadth 238	Length 293

TABLE 5. Scapular and forelimb measurements (in mm) of QM JM11761. * = possibly missing.

	Scapula		Humerus, Radius, Ulna				
	Right	Left		Breadth		Length	
Greatest breadth	570	572		Right	Left	Right	Left
Greatest height	349	349	Humerus	126	130	251	254
Ratio of breadth to height	1.6	1.6	Radius	76	75	385	390
Length of acromion-inferior	124	119	Ulna	49	49	347	352
Breadth of acromion, distal end	46	40					
Length of coracoid, inferior	77	73					
Breadth of coracoid, distal end	28	30					
Length of glenoid fossa	135	132					
Breadth of glenoid fossa	90	90					

Length of Phalanges								
Phalanx	Right				Left			
	I	II	III	IV	I	II	III	IV
1	57	71	57	46	57	71	57	46
2	59	72	61	43	59	74	61	43
3	49	54	50	35	48	55	50	35
4	27	36	36	6	29	37	36	
5		25	24			24	23	
6		15	14			15	15	
7		7	*			7	5	
8		*				*		